Growth and carcass performance of bull calves born from Hereford, Simmental and Charolais cows sired by Charolais bulls

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ABSTRACT: The analysis comprised purebred Charolais bull calves (CH) and crossbred bull calves born from Hereford (CH × HE) and Simmental (CH × SI) cows. Body weights and daily gains were measured in subsequent periods of the experiment and the post-slaughter evaluation was carried out. Carcass lean weight and dressing percentage were evaluated, as well as the lean content of five prime cuts. Total weight of the five prime cuts was measured and its share in the half-carcass weight was determined. The rib-eye area was also measured. The CH × SI crossbreds reached significantly higher body weights at weaning, 210-day body weights and weights at finishing, as well as significantly higher daily gains in all the periods ($P < 0.05$, $P < 0.01$) and were characterized by the heaviest carcasses and most cuts, particularly the round. The crossbreds had the highest total weight of five prime cuts and total lean weight, highest weight of the round and lean weight in the round. Other relationships were found analyzing the share of each cut in the carcass. The share of tenderloin and rump in the carcass of CH × SI was significantly lower compared to the purebred bulls ($P < 0.01$) and CH × HE ($P < 0.05$). They also had a significantly lower share of the shoulder, shank and shin, as compared to the other groups, as well as a significantly higher ($P < 0.05$) share of the neck, as compared to the purebred bulls. The purebred bulls also achieved good results and had the highest share of the prime cuts and the largest mean rib-eye area.

Keywords: beef bull calves; crossbreds; body weight; daily gains; carcass performance

Beef production in Poland is mostly based on the breeds that are used in dairy or beef-dairy production. The farming of typical beef cattle breeds did not begin until the beginning of the 1990s, when the "Program of Beef Cattle Production Development for Poland" was approved, which involved state financial aid offered to producers in the form of subsidies or low-interest loans. Such situation at that time resulted in increased import of purebred breeding-stock heifers, most often from European countries (France, Denmark, Germany, Czech Republic etc.) and, to a lesser extent, from the USA and Canada. At present, crossbreeding involves mostly Polish dairy cows (HF) and beef bulls, including absorptive crossing aimed at obtaining a desirable beef breed, as well as purebred beef cattle breeding. Much research has been carried out in this area (Lis et al., 2000; Stenzel et al., 2001; Przysucha and Grodzki, 2004; Wajda et al., 2006; Pilarczyk and Wójcik, 2007). Beef breed cross-

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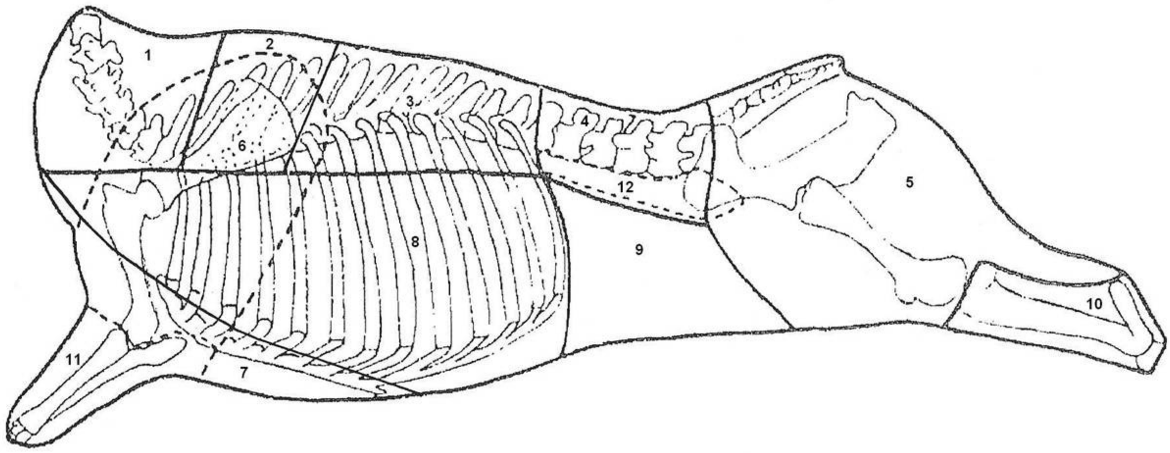

Figure 1. Scheme of carcass dissection: 1 – neck; 2 – foreribs; 3 – entrecote; 4 – rump; 5 – round; 6 – shoulder; 7 – brisket; 8 – plate; 9 – flank; 10 – shank; 11 – shin; 12 – tenderloin

breeding has been applied in few herds; however, we are expecting an intensive growth of importance of this system. The aim of this study was to evaluate the results of fattening and carcass performance of purebred Charolais bull calves and crossbred bull calves born from Hereford and Simmental cows sired by Charolais bulls.

MATERIAL AND METHODS

The material comprised 30 bull calves in three groups (10 individuals each):
– purebred Charolais (CH);
– crossbreds obtained from Hereford dams sired by Charolais (CH × HE);
– crossbreds obtained from Simmental dams sired by Charolais (CH × SI).

Calves in all groups were derived from the same herd and were raised together under the same conditions. Cows were inseminated with semen of 10 bulls, mainly from France. Each group contained a representative number of calves obtained from these sires.

The calves born in March and April (in 2002) remained with their dams until October, being fed entirely on maternal milk and grazing during this period.

After weaning, fattening feeding was carried out indoors. It was assumed that the bulls would be slaughtered at approx. 18 months of age with a minimum body weight of 550 kg. The fatteners were fed

Table 1. Chemical composition and nutritional value of applied feeds

Specification	Pasture green forage	Meadow hay	Bruised barley	Grass and clover silage
Dry matter (%)	23.61	81.06	80.72	49.00
Metabolic energy (MJ/kg DM)	10.63	9.68	13.20	10.73
Crude protein (g/kg DM)	190.20	174.70	157.30	136.10
Crude fat (g/kg DM)	64.80	31.90	24.50	48.20
Crude fibre (g/kg DM)	391.80	329.40	46.20	367.50
Nitrogen-free extract (g/kg DM)	270.60	397.50	753.40	368.80
Ash (g/kg DM)	82.60	66.50	18.60	79.40
Score (points)				88
General assessment				very good

on grass and clover silage in winter (18 kg per head per day), lucerne green forage in summer (30 kg per head per day) and hay all the year round (3 kg per head per day), as well as barley (3 kg per head per day) and mineral supplement (80 g per head per day). Chemical composition of the feeds and their nutritional values are presented in Table 1. The silage was evaluated as "very good" (88 points) according to the 100-point Flieg-Zimmer scale. Other feeds were also of a good quality.

The animals were weighed at birth and at weaning, as well as when they reached the finish body weight (at about 18 months of age). We calculated 210-d body weight, and daily gains from birth to weaning and to finishing, as well as from weaning to finishing.

Finished bulls were slaughtered after 12-hour fasting and the post-slaughter evaluation was carried out. The average age of a bull on the day of slaughter was 524 days. Carcass weight and dressing percentage were determined. The right half-carcasses, after chilling, were cut (according to Polish Norms): neck, foreribs, entrecote, rump, shoulder, brisket, plate, flank, shank, and shin. The cuts were weighed to the nearest 0.01 kg. The weight of the cuts and the share of each cut in the carcass were determined, as well as the weight and share of the lean in five prime cuts. The weight of five prime cuts and their shares in the carcass, as well as the rib-eye area (*longissimus dorsi* muscle, between the 12th and 13th thoracic vertebra) were also measured. Figure 1 presents the procedure of carcass dressing.

The resulting data were processed statistically using one-way ANOVA and multi-range Duncan's test, by means of the Statistica PL 7.0 package.

RESULTS

Body weights and daily gains of bull calves for the particular periods are presented in Table 2. The highest body weights at birth were found in the purebred bull calves while they were significantly ($P < 0.01$) heavier than the crossbreds. The CH × SI crossbreds reached significantly higher body weights at weaning, 210-day body weight, and at finishing, as well as significantly higher daily gains in all the periods ($P < 0.05$, $P < 0.01$). The worst results were attained by the CH × HE crossbreds, which had significantly lower 210-day body weight and weight at finishing, and attained significantly lower daily gains during the periods from birth to weaning and from birth to finishing.

Carcass weight, dressing percentage and the share of each cut in the carcass are presented in Table 3. The CH × SI crossbreds were characterized by significantly ($P < 0.05$, $P < 0.01$) higher finish body weight and carcass weight, as compared with the purebred bull calves CH and with the CH × HE crossbreds. As a result of larger carcasses,

Table 2. Body weights and daily gains by periods of life

Specification	CH		CH × HE		CH × SI	
	mean	SD	mean	SD	mean	SD
Body weigh (kg): at birth	41.7^{A,B}	1.70	39.4^{A}	1.52	38.2^{B}	1.28
At weaning	267.5	41.21	243.8	23.38	281.1	26.25
210-day body weight	243.1	30.98	218.1^{a}	19.46	251.2^{a}	19.44
Final weight	554.0^{a}	34.11	560.0^{b}	28.28	592.0^{a,b}	24.07
Daily gains (g): pre-weaning	959^{a}	145	851^{A,a}	92	1 013^{A}	115
From birth to slaughter	993	103	951^{a}	46	1 076^{a}	75
Post-weaning	1 020^{a}	96	1 029^{b}	52	1 128^{a,b}	100
Age at weaning (days)	234.6	8.7	240.4	12.2	239.7	6.0
Age at slaughter (days)	517.9	32.4	547.4	12.2	517.1	41.4

^{a,b}the same lower case letters denote statistically significant differences at $P < 0.05$
^{A,B}the same upper case letters denote statistically significant at differences $P < 0.01$

Table 3. Dressing percentage, weights of cuts and their shares in the carcass

Specification	CH		CH × HE		CH × SI	
	mean	SD	mean	SD	mean	SD
Weight at slaughter (kg)	523.1[a]	22.11	532.0[b]	26.87	568.1[a,b]	16.99
Carcass weight (kg)	299.1[A]	13.82	302.9[B]	13.33	332.2[A,B]	12.54
Dressing percentage (%)	57.2	1.84	56.9	1.26	58.5	1.37
Weight (kg): Entrecote	10.21	0.58	9.83	0.09	10.62	1.00
Tenderloin	3.73	0.09	3.57	0.29	3.39	0.35
Round	43.50[A]	2.14	42.71[B]	2.04	48.02[A,B]	1.76
Rump	7.85	0.40	7.65	0.60	7.80	0.40
Shoulder	19.54	1.13	19.71	0.47	20.51	0.65
Shin	7.60	0.44	7.67	0.18	7.98	0.25
Plate	10.54[a]	0.42	11.49	1.04	12.89[a]	1.73
Foreribs	9.69	0.83	9.11	1.80	10.82	1.63
Neck	12.57[a]	0.99	14.06	1.18	17.95[a]	4.82
Shank	8.96	0.29	9.12	0.57	8.85	0.43
Flank	6.98[a]	0.80	7.85	0.71	8.88[a]	1.43
Carcass share (%): Entrecote	6.86	0.32	6.53	0.29	6.43	0.73
Tenderloin	2.51[A]	0.09	2.37[a]	0.21	2.06[A,a]	0.28
Round	29.22	0.28	28.32	0.50	29.03	0.94
Rump	5.27[A]	0.06	5.07[a]	0.23	4.72[A,a]	0.30
Shoulder	13.12[a]	0.33	13.08[b]	0.44	12.41[a,b]	0.58
Shin	5.10[a]	0.13	5.09[b]	0.17	4.82[a,b]	0.23
Plate	7.09	0.29	7.61	0.38	7.77	0.76
Foreribs	6.50	0.33	6.02	0.99	6.55	1.04
Neck	8.45[a]	0.66	9.31	0.48	10.79[a]	2.68
Shank	6.03[A]	0.33	6.05[B]	0.25	5.35[A,B]	0.22
Flank	4.68	0.43	5.20	0.37	5.35	0.72

[a,b]the same lower case letters denote statistically significant differences at $P < 0.05$
[A,B]the same upper case letters denote statistically significant at differences $P < 0.01$

the CH × SI bulls reached higher weights in most cuts, except for tenderloin and rump, which were heavier in the purebred bulls; brisket and shank, on the other hand, were larger in CH × HE. Particularly interesting is higher weight of the round ($P < 0.01$) in the CH × SI crossbreds compared to the other groups (by 4.52 and 5.31 kg, respectively). The CH × SI crossbreds were also characterized by significantly ($P < 0.05$) heavier plate, neck and flank, as compared to the purebred bulls. Other relationships were found analysing the share of each cut in the carcass. The highest share of the prime cuts, i.e. entrecote, tenderloin, round, rump and shoulder, as well as less valued shin, was achieved by the purebred bulls. The highest share of brisket and shank was observed in the CH × HE crossbreds, while the CH × SI exhibited the highest share of plate, foreribs, neck and flank. The share of tenderloin and rump in the carcass of CH × SI was significantly lower compared to the purebred bulls ($P < 0.01$) and CH × HE ($P < 0.05$). These also had a significantly lower share of shoulder, shank and shin, as compared to the other groups, as well as a significantly higher ($P < 0.05$) share of the neck, as compared with the purebred bulls.

The dissection of the five prime cuts (Table 4) revealed the highest weight of the lean in entrecote, foreribs, shoulder and round in the CH × SI crossbreds, while the purebred calves produced the heaviest rump. It should be stressed that the round lean weight in the CH × SI crossbreds was much higher, by 4.35 kg and 5.01 kg, respectively, than that observed in the purebred bulls and CH × HE crossbreds, which was confirmed statistically ($P < 0.01$). Lean weights in the remaining four cuts were similar, except for the foreribs of the CH × SI bulls, which was more than 1 kg higher. The highest lean content was found in foreribs, entrecote and round of the CH × SI crossbreds. Lean shares in the cuts of these crossbreds were higher compared to the purebred bulls and CH × HE crossbreds, by 2.83 and 4.32%, respectively, in the entrecote, 1.85 and 1.47% in the foreribs, and 1.50 and 1.51% in the round. The highest lean content in the rump was found in the purebred bulls, which was 4.16% higher than in the CH × SI crossbreds.

The CH × SI crossbreds were also characterised by the highest total weight of prime cuts, which was significantly higher as compared with the remaining groups. The share of the prime cuts in the carcass ranged between 59.02% in the CH × HE bulls and 60.97% in the purebred bulls. The lean content in the prime cuts was also similar in all the groups; however, the highest value was found in the CH × HE crossbreds. The largest mean rib-eye area was observed in the purebred bulls (122.07 cm^2), whilst the smallest in the CH × HE bulls (106.07 cm^2), which was statistically significant ($P < 0.05$).

DISCUSSION

Crossbreeding is widely used in the beef industry to increase production. Review articles by Gregory

Table 4. Prime cuts

Specification	CH		CH × HE		CH × SI	
	mean	SD	mean	SD	mean	SD
Total weight of 5 prime cuts (kg)	90.79^{a}	4.75	89.04^{A}	4.33	97.77^{A,a}	2.50
Carcass share of 5 prime cuts (%)	60.97	0.86	59.02	0.73	59.14	2.36
Lean weight (kg) in: Entrecote	6.57	042	6.18	0.30	7.14	0.91
Foreribs	7.27	0.71	6.90	1.55	8.33	1.36
Round	35.23^{A}	2.34	34.57^{B}	2.05	39.58^{A,B}	1.19
Rump	5.08	0.39	4.87	0.28	4.72	0.37
Shoulder	14.70	1.15	14.83	0.25	15.40	0.73
Lean content (%) in: Entrecote	64.34	1.77	62.85	3.20	67.17	4.73
Foreribs	75.00	2.28	75.38	2.41	76.85	1.71
Round	80.94	1.91	80.93	2.41	82.44	1.00
Rump	64.69	3.29	63.83	3.97	60.53	3.89
Shoulder	75.15	1.70	72.23	0.64	75.07	1.22
Total lean weight in 5 prime cuts (kg)	68.86^{a}	4.47	67.33^{A}	3.44	75.14^{A,a}	1.83
Lean content in 5 prime cuts (%)	75.81	1.33	75.65	1.14	76.85	0.76
Rib-eye area (cm^2)	122.07^{a}	10.59	106.07^{a}	6.37	114.74	8.48

^{a,b}the same lower case letters denote statistically significant differences at $P < 0.05$

^{A,B}the same upper case letters denote statistically significant at differences $P < 0.01$

and Cundiff (1980), Long (1980) and DeRouen et al. (1992a,b) indicated that crossbreeding is an effective tool to make use of breed differences and to generate heterosis.

Our studies have revealed that the Charolais bulls were heavier at birth than the crossbreds; however, other authors (Jakubec et al., 2003; Przysucha and Grodzki, 2004; Krupa et al., 2005; Pilarczyk and Wójcik, 2007), who studied purebred HE and SI bulls, observed lower weights at birth compared with the crossbreds analysed in the presented studies. Body weight at birth in the Charolais breed ranges from 35.7 kg to 46.6 kg (Jakubec et al., 2003; Przysucha and Grodzki, 2004; Krupa et al., 2005). Wolfová et al. (2004) observed that CH × SI bulls had 40.5 kg on average at birth.

Body weight at weaning, 210-d body weight, and daily gains from birth to weaning were the highest in the CH × SI crossbreds. It should be noted that the CH × HE crossbreds attained the worst results, much worse compared to the purebred bull calves. Compared to the CH bulls, the CH × SI bulls reached more than 5% higher weight at weaning and daily gains from birth to weaning, while these traits were lower in the CH × HE crossbreds by 9% and 11%, respectively. Nearly all comparable studies reported a negative direct maternal effect of the HE dam on the body weight at weaning of the progeny (Alenda et al., 1980; Franke et al., 2001, Dadi et al., 2002). Dillard et al. (1980) concluded that the lower weight at weaning reached by crossbreds from HE dams was probably due to the fact that HE dams did not have enough milk and maternal ability to maximise the growth of calves, crossed with Charolais. Dadi et al. (2002) found that most crossbred calves from HE dams were characterised by lower body weight at weaning compared to those from dams of other breeds. The negative effect of Hereford cows was also demonstrated by Skrypzeck et al. (2000). Dillard et al. (1980) also reported a stronger Charolais dam effect than sire effect for the heterosis of body weight at birth and at weaning in crossbred calves.

Simmental and Charolais are breeds of high growth rate during the rearing period, mainly due to very high milk yield of their dams. As a result of heterosis, crossbreds of these breeds reach very good gains and high body weights during rearing compared to purebred calves. The milk yield of dams belongs to the most important factors affecting the body weights of calves at weaning. Clutter and Nielsen (1987) as well as Minick et al. (2001) concluded that the milk yield is responsible for daily gains of calves at 60%, and the high-yielding cows nurse calves that are heavier at weaning. Numerous reports state that the highest milk yield is attained by Simmental cows, while Hereford cows reach definitely worse results (Fiss and Wilton, 1992; Gregory et al., 1992). The Simmental breed, besides Charolais and Blonde d'Aquitaine, attains the highest body weights with the fastest growth rate (Jakubec et al., 2003; Přibyl et al., 2003; Krupa et al., 2005). In the presented studies, the CH × SI crossbreds also reached the highest gains during finishing (from weaning to the end of fattening). It should be stressed that the bulls of all groups reached very good daily gains during finishing, amounting to more than 1 000 g. Over the entire feeding period, good-quality feeds were fed, which resulted in high finishing performance. The purebred bull calves and CH × HE crossbreds were characterised by similar gains during this period, however, the fattening of the CH × HE crossbreds was one month longer.

The studied CH × SI crossbreds also had significantly higher carcass weight, total weight of five prime cuts and total lean weight of these cuts, heavier round, and higher lean weight of the round. These very good results are probably due to the effect of heterosis resulting from crossing the cattle of two breeds that are characterised by a high slaughter value, higher than that of Hereford. A number of studies has confirmed that bulls of Charolais and Simmental are characterised by a significant dressing percentage compared to Hereford bulls, with Charolais having this parameter usually higher than Simmental (Sakowski et al., 2001; Sochor et al., 2005; Bartoň et al., 2006). The studies by Oprządek et al. (2001) revealed a higher share of the round in the carcass of Charolais bulls compared to that of Hereford and Simmental bulls; Hereford bulls, on the other hand, had a higher shoulder share. Charolais and Simmental bulls exhibited a similar share of prime cuts (61.2% of the half-carcass), while Hereford bulls had it significantly lower (60.2%). The lean content in the five prime cuts was also higher in Charolais and Simmental bulls, as compared with Hereford bulls. The purebred Charolais bulls discussed here were characterised by a significantly higher share of prime cuts in the carcass (rump, tenderloin and shoulder) and a higher mean rib-eye area. Sakowski et al. (2001) reported a similar weight and carcass share of prime cuts in Charolais bulls to those obtained in our studies. In the present studies, the share of each cut in the carcass was higher in the crossbreds compared to the purebred bulls studied by Oprządek et al. (2001). According to Bartoň et al. (2006), purebred Charolais and Simmental bulls were characterised by significantly higher dressing percentage and content of prime cuts in the carcass compared with Hereford bulls; however, the rib-eye area was similar. Crossbred Charolais × Czech Fleckvieh bulls had s similar slaughter value compared to purebred Charolais bulls, according to Bartoň et al. (2007). Positive heterosis for carcass weight was found in numerous studies (Hedrick et al., 1975; Koch et al., 1983; Neville et al., 1984).

The other important advantage resulting from crossbreeding is the potential of two or more breeds to produce offspring with optimum performance within several traits. British breeds such as Hereford generally excel in marbling potential, whereas Continental breeds (for example Charolais) are typically superior for red meat yield (cutability). Combining the breed types results in offspring that have desirable levels of both quality grade (marbling) and retail yield (yield grade). Similarly, milk production and growth rate may be optimized most efficiently by crossing two or more breeds (Alenda et al., 1980; DeRouen et al., 1992a). Crossing Hereford with Charolais cattle, we can expect the crossbreds to have better growth rate and slaughter value than purebred Hereford.

Neumann (2002) reported that Charolais and their crosses with Simmentals (the synthetic line Uckermärker) were the most important among several beef breeds in Germany. In pure breeding and crossbreeding (Simmental × Charolais), these breeds give a desired product, since the bright colour of meat is preferred by the buyers. Long-term experience enables to choose the most efficient fattening methods and to select the well-tried and tested breeds.

To recapitulate, the best performance parameters were reached by the CH × SI crossbreds, which exhibited the highest body weights at weaning and at slaughter, the highest daily gains in all the periods of production, and produced the heaviest carcasses. It was also observed that the crossbreds produced the highest total weight of five prime cuts and total lean weight, highest weight of the round and lean weight of the round. The purebred bulls also achieved good results, having the highest share of prime cuts in the carcass as well as the largest mean rib-eye area. The results indicate that, under the studied conditions, the analysed purebred Charolais bulls and their beef crossbreds are good for the production of high-quality beef.

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